

$$\sqrt{\left\{ v^2 + \left( \frac{V-v}{5} \right)^2 \right\}}.$$

The smallest admissible value of  $v$  (in an algebraical sense) is that which makes the orbit round the Sun parabolic, supposing the meteors subject to the law of gravitation. This gives

$$v^2 + \left( \frac{V-v}{5} \right)^2 = 2 V^2,$$

of which the negative solution is  $v = -V \times 1.32$ . From this, the absolute velocity perpendicular to the ecliptic

$$= \frac{V-v}{5} = V \times 0.464;$$

and, as the meteors were then at the node, and the velocity  $v$  is perpendicular to the line of nodes, the tangent of the inclination of the orbit to the ecliptic is  $= \frac{0.464}{1.32} = 0.35$  nearly, or the inclination is  $= 19^{\circ} \frac{1}{4}$ .

The largest admissible value of  $v$  is that beyond which the meteors would have been seen receding towards the vanishing point, or that which would have made them appear stationary. This gives  $V-v=0$ ; motion towards the ecliptic  $=0$ ; velocity parallel to the Earth's motion is  $=V$ ; tan. inclination of orbit is  $= \frac{0}{V} = 0$ .

We may therefore conclude that the inclination of the orbit of the meteors to the ecliptic is less than  $19^{\circ}$ .

If the absolute motion of the meteors in the direction of the Earth's movement on Nov. 13-14 was very small, the eccentricity of their orbit would not be great; but in any other case it would be considerable.

*Royal Observatory, Greenwich, 1866, December 10.*

*On the Meteor Shower of 1866, November 13-14.*  
By Piazzi Smyth, Esq., Astronomer Royal for Scotland.

Agreeably with the important letter of Mr. A. S. Herschel, circulated by the President of the Royal Astronomical Society, meteoric shooting-stars were looked for here on the nights of the 12th and 13th instant.

On the 12th the sky was nearly covered with cloud; long,

hazy bands of which were radiating out of the E. N. East, and probably converging in the W. S. West,—but that quarter was usually too full of rain-squalls driven by the wind, itself nearly W. S. West, to allow of much being seen there.

Between the appointed hours of 1 and 2 A.M., only two shooting-stars were observed, both rising in their paths, and with a tendency from east to west, one of them below, and the other above, the stars of the *Great Bear*, which were only just visible through a space partially cleared of haze. The meteors appeared of about the brightness of stars of the first or second magnitude, had no visible trains, and the direction of their paths, produced backwards, converged on a centre not far above the eastern point of the horizon.

About 3<sup>h</sup> A.M. another meteor was seen, of the same moderate brightness; but it was coursing along above the south and south-east horizon, and in a direction retrograde to the other two, or proceeding from west to east directly to the point which they had seemed to have emerged from.

The night of the 13th was very different, the sky being exquisitely clear, the stars everywhere very brilliant, and nothing extraneous to interfere with the astronomical features, except a little auroral light, low down on the N. N. West, and E. N. East horizons, and a few small patches of dark vapour in front of it.

Soon after 11<sup>h</sup> P.M. shooting-stars began to be noticed as frequent; towards midnight, they were very noticeable; at 0<sup>h</sup> 10<sup>m</sup> A.M. an excessively brilliant one occurred, causing distinct shadows of dark objects to appear on the ground, and leaving a luminous track in the sky, near the three stars in the head of *Cepheus*, visible for nearly 12 minutes. The number of more ordinary shooting-stars was increasing all the time, and was probably at its maximum at 0<sup>h</sup> 54<sup>m</sup> A.M., when half-a-dozen were often visible together.

Upwards of 1000 had now been noted, though only in an irregular manner; but from 0<sup>h</sup> 58<sup>s</sup> to 1<sup>h</sup> 58<sup>m</sup> A.M. Greenwich Mean Time, they were observed more steadily by one observer looking towards the east, and an assistant noting the times, and with the result of 1492 being registered in the interval.

But this was by no means the whole number which the heavens displayed, for during the last half of this period a second observer watched towards the N. W. and registered rather more than half the numbers of the eastern observer. Although, too, some of them may be the same as his, others again, and even a large proportion, the N. W. observer was certain, only began their visible flights somewhat west of the meridian. Hence, if we allow him only two-thirds his numbers, but imagine another observer stationed towards the S. W. and another again regarding only the zenith region of the sky, they would, amongst them, have had at least as many original meteors as the first observer looking east, so that his

numbers should be doubled, and 2984 be stated as the approximate number of meteors for that hour.

The numbers of these meteors, as taken minute by minute, were rather rough and conflicting; but on taking the sums of every successive *ten* minutes, an admirable regularity of continually decreasing numbers immediately showed itself, proving, without a single anomaly, that the meteors were decreasing through the hour; that the maximum had occurred before 1 o'clock A.M., and that in two hours, symmetrically arranged about the period of maximum, something over 6000 meteors must have occurred.

Or more accurately, by projecting the numbers observed, and drawing curves through them, the time of maximum may be regarded as 0<sup>h</sup> 54<sup>m</sup> A.M. and the total number of meteors over one hour, including that maximum

|                                    |   |   |   |   |      |
|------------------------------------|---|---|---|---|------|
| in its middle point,               | . | . | . | . | 4626 |
| over two hours, similarly situated | . | . | . | . | 6426 |
| four        "        "             | . | . | . | . | 7680 |
| eight       "       "              | . | . | . | . | 8312 |

The observations were discontinued at 4<sup>h</sup> 30<sup>m</sup> A.M., when the number of meteors seemed to be only 3 against 89 at 0<sup>h</sup> 56<sup>m</sup> A.M.

The general characters of these meteors were, bright yellow balls, like *Jupiter* or *Venus* for brightness, but attended by long trains of faint and light-blue light; these trains usually lasted only from two to three seconds, were of an exaggerated long elliptical form, so as to be nearly invisible close to the bright head, and to be broadest near the middle of their length; and such broader central part of the train often remained abundantly visible long after the head, and chief part of the length of the train, had entirely disappeared; so decidedly too was this a material fact, and not any optical impression caused by the overpowering brightness of the head during the time it was visible, that often, on turning to a new part of the sky, the last expiring traces of such short central part of a meteor track were seen, proving that a meteor had just passed that way and been missed by the observer.

Some years since, an abundant display of meteors was compared to flakes of snow in a snow-storm; but that simile was by no means descriptive of the leading impressions of the scene on the 13th; for, excepting one small region of the sky presently to be noticed, there was a velocity, a certainty, and an almost apparent purpose in the motion of every meteor, quite apart from the uncertain characteristics of feathery snow. Without knowing anything at all of the actual distances of these bodies, they gave the impression of some ethereal description of rockets, but endued with the speed of cannon-balls, and half their purity of path; and one of them often followed

another, second after second, for several seconds together, as if discharged from the other side of the sky at something positive in the West, and with a determination to hit it too. One, and only one, case of directly retrograde motion was observed; a moderate number of crossing paths were noticed; but the immense majority of all cases, whether the motions were through the zenith, over the north or south horizons, was from East to West; and in a manner implying an original divergence from an eastward position, with an apparent separation overhead from perspective, and a convergence again towards the West.

The point of origin in the East was very visible among the stars of *Leo*; and not only were many of the larger trained and brighter meteors seen to emerge from that quarter, but many very short-trained, and apparently distant ones, were seen there, and there only. For a time indeed, about one o'clock, there seemed to be a glow of infinite numbers of distant, and not individually visible, meteors, in that direction, from its coinciding with the auroral light thereabout; but by two o'clock the constellation had risen above that accidental effect, and had carried the point of meteor origin so decidedly with it,—that whereas previously all the meteors were seen more or less rising upwards through the sky, though to different azimuths,—there were afterwards seen almost as many descending from that point to the horizon underneath it.

To test this important feature, a drawing was made of the sidereal sky as it appeared in the East at 2<sup>h</sup> 5<sup>m</sup> A.M., and from that moment to 2<sup>h</sup> 15<sup>m</sup> every meteor was marked on the paper, just as seen by the eye at the same instant among the stars in that quarter of the heavens, and the practical result is shown in the copy now transmitted.

Of particular meteors, it may be mentioned, that in addition to the instance alluded to above at 0<sup>h</sup> 10<sup>m</sup> A.M., there was another at 0<sup>h</sup> 59<sup>m</sup> 30<sup>s</sup>, momentarily near the zenith, bright enough to illumine the interior of a dark room, and then descending apparently in two or three red pieces, nearly through the line of the tail of the *Great Bear*; and there must have been another about 2<sup>h</sup> 40<sup>m</sup> A.M. between  $\alpha$  *Ursæ Majoris* and  $\alpha$  *Ursæ Minoris*, for immediately thereafter the central part of its luminous track was brilliantly conspicuous, like a silver snake in the sky. From minute to minute the luminous line became more corrugated; widening and becoming fainter by degrees; and also drifting, apparently under the action of the N. W. wind blowing at the time; even after a quarter of an hour the train matter was still visible, but changed to something like the outline of a gigantic pear, and drifted some 30° from its first position.

Both this meteor and that of 0<sup>h</sup> 10<sup>m</sup> may be considered to have entered the Earth's atmosphere, and to have terminated their careers as planetary bodies revolving around the Sun;

but these were in a proportion of less than 1 in 1000 of those which had every appearance of going past the Earth altogether, and having a chance therefore of being seen again on another Nodal passage.

The drawing, and the principal numerical particulars alluded to above, are appended to this Note, which I regret is not more worthy of the magnificent meteoric display of which it attempts to chronicle only some leading features.

Royal Observatory, Edinburgh,  
14th November, 1866.

999  
See how  
D

Number of Meteors seen by an Observer looking Eastward,  
and Registered by another :

| During the<br>Minute<br>ending.<br>h m | Number. | During the<br>Ten Minutes<br>ending:<br>h m | Number. | During the<br>Hour<br>ending:<br>h m | Number. |
|--|---------|---|---------|--------------------------------------|---------|
| 0 59 A.M.                              | 28      |   |         |                                      |         |
| 1 0                                    | 30      |   |         |                                      |         |
| 1 1                                    | 32      |   |         |                                      |         |
| 1 2                                    | 60      |   |         |                                      |         |
| 1 3                                    | 60      |   |         |                                      |         |
| 1 4                                    | 30      |   |         |                                      |         |
| 1 5                                    | 36      |   |         |                                      |         |
| 1 6                                    | 34      |   |         |                                      |         |
| 1 7                                    | 64      |   |         |                                      |         |
| 1 8                                    | 38      | 1 8 A.M.                                    | 412     |                                      |         |
| 1 9                                    | 38      |   |         |                                      |         |
| 1 10                                   | 29      |   |         |                                      |         |
| 1 11                                   | 30      |   |         |                                      |         |
| 1 12                                   | 40      |   |         |                                      |         |
| 1 13                                   | 41      |   |         |                                      |         |
| 1 14                                   | 40      |   |         |                                      |         |
| 1 15                                   | 35      |   |         |                                      |         |
| 1 16                                   | 35      |   |         |                                      |         |
| 1 17                                   | 52      |   |         |                                      |         |
| 1 18                                   | 50      | 1 18 A.M.                                   | 390     |                                      |         |
| 1 19                                   | 44      |   |         |                                      |         |
| 1 20                                   | 31      |   |         |                                      |         |
| 1 21                                   | 30      |   |         |                                      |         |
| 1 22                                   | 29      |   |         |                                      |         |
| 1 23                                   | 29      |   |         |                                      |         |
| 1 24                                   | 33      |   |         |                                      |         |
| 1 25                                   | 30      |   |         |                                      |         |
| 1 26                                   | 23      |   |         |                                      |         |

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28 *Mr. Piazzi Smyth, on the Meteoric Shower of Nov. 13-14.*

| During the<br>Minute<br>ending:<br>h m | Number. | During the<br>Ten Minutes<br>ending:<br>h m | Number. | During the<br>Hour<br>ending:<br>h m | Number. |
|--|---------|---|---------|--------------------------------------|---------|
| I 27                                   | 23      |   |         |                                      |         |
| I 28                                   | 23      | I 28 A.M.                                   | 295     |                                      |         |
| I 29                                   | 20      |   |         |                                      |         |
| I 30                                   | 7       |   |         |                                      |         |
| I 31                                   | 6       |   |         |                                      |         |
| I 32*                                  | 20      |   |         |                                      |         |
| I 33                                   | 20      |   |         |                                      |         |
| I 34                                   | 20      |   |         |                                      |         |
| I 35                                   | 20      |   |         |                                      |         |
| I 36                                   | 20      |   |         |                                      |         |
| I 37                                   | 17      |   |         |                                      |         |
| I 38                                   | 18      | I 38 A.M.                                   | 167     |                                      |         |
| I 39                                   | 16      |   |         |                                      |         |
| I 40                                   | 16      |   |         |                                      |         |
| I 41                                   | 16      |   |         |                                      |         |
| I 42                                   | 16      |   |         |                                      |         |
| I 43                                   | 12      |   |         |                                      |         |
| I 44                                   | 11      |   |         |                                      |         |
| I 45                                   | 11      |   |         |                                      |         |
| I 46                                   | 11      |   |         |                                      |         |
| I 47                                   | 11      |   |         |                                      |         |
| I 48                                   | 11      | I 48 A.M.                                   | 131     |                                      |         |
| I 49                                   | 11      |   |         |                                      |         |
| I 50                                   | 11      |   |         |                                      |         |
| I 51                                   | 11      |   |         |                                      |         |
| I 52                                   | 10      |   |         |                                      |         |
| I 53                                   | 9       |   |         |                                      |         |
| I 54                                   | 9       |   |         |                                      |         |
| I 55                                   | 9       |   |         |                                      |         |
| I 56                                   | 9       |   |         |                                      |         |
| I 57                                   | 9       |   |         |                                      |         |
| I 58                                   | 9       | I 58 A.M.                                   | 97      | I 58 A.M.                            | 1492    |

\* From 1<sup>h</sup> 32<sup>m</sup> to 2<sup>h</sup> 2<sup>m</sup> A.M. the meteors were counted and the time entered only for every even hundred ; and from thence have been arithmetically distributed through the included minutes.